Using GOCE satellite gravity data for the exploration of the African lithosphere

A.Peyrefitte, M.Diament, G.Martelet, S.Bonvalot

The GOCE (Gravity field and steady-state Ocean Circulation Explorer) satellite mission, launched by the European Space Agency (ESA) in 2009, aims to map the Earth's gravity with unprecedented detail (1°x1° at global scale). It provides a new class of gravity observations (gradiometric measurements) that can be used to investigate the lithospheric structures and processes from regional to global scales. The African continent is characterized by ancient cratons as well as more recent orogenic belts and large basins which, in place, are affected by recent to actual intraplate volcanism, rifting or hotspots. This complex geology attests for past and on-going tectonic and geodynamic processes which affect the African plate at the lithospheric scale. Such patterns are well known to provide a large variety of density contrasts, so gravity data gathered from ground or airborne surveys are extensively used since several decades to investigate the crustal or lithospheric structures of the African plate. We present here the first gravity maps (Fig.1) computed from GOCE datasets shortly delivered and discuss their use for understanding the main structural patterns of the African lithosphere and the geodynamic processes.

Comparison of the model deduced from the 2 first months GOCE data with EGM2008 model based on ground surveys and satellite data shows significant differences over Africa mainly related to the heterogeneous ground data distribution (see Fig.2).

Our aim is to investigate the crustal gravity signature of the entire African plate in order to 1- better discriminate between mantle and crustal gravity signatures and 2- bring constraints on the crust itself.

For this purpose, we realized a first 3D forward model in which the African crust is discretized in spherical prisms, by jointly using two global seismological models: CRUST 2.0 and the global digital map of sediment thickness. Our model consists of three sedimentary and three crystalline crust layers and has a spatial resolution of 1°x1°. We computed the gravity (Fig.3) and tensor component effects of our model using a dedicated software based on a discretization into spherical prisms developed by Uieda et al.

We substracted this gravity effect to a Bouguer map that we derived from the first GOCE-based free air anomalies.

Short wavelength residuals attest for shortcomings in the input crustal seismological model. Long wavelength residuals highlight mantellic gravity components which reflect deep thermal/compositional variations, such as the effect of the African Superplume.

Then, we will take full advantage of the availability of the gravity gradients by incorporating them in the inversion process to improve the crustal density structure of our model.

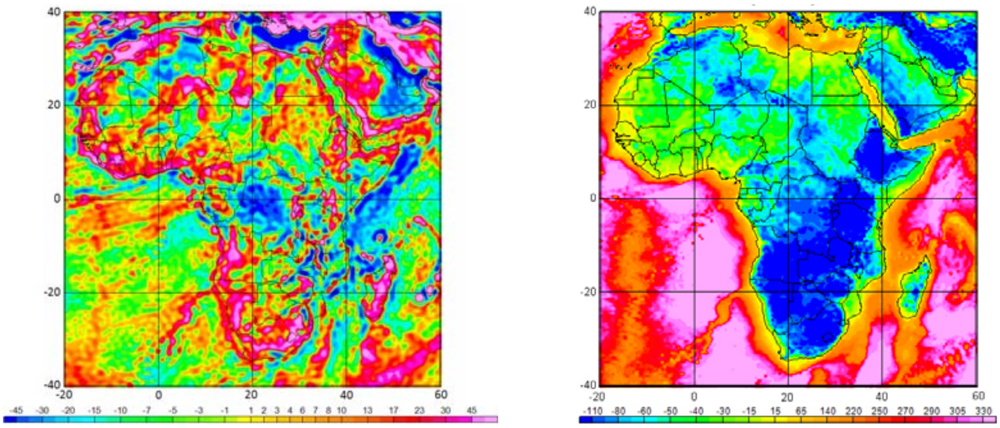

Figure 1: Free air and Bouguer anomalies computed from the first GOCE gravity model (mGal)

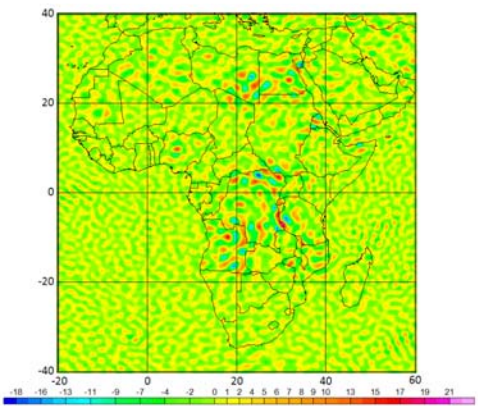

Figure 2: Difference between EGM2008 and model deduced from first GOCE data (mGal)

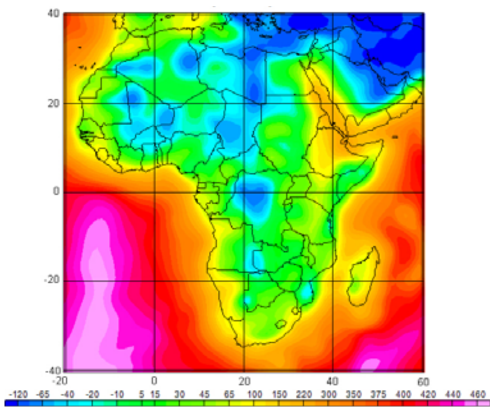

Figure 3: Gravity response of the 3D forward model computed in spherical geometry (mGal)